THEREFORE WHAT IS CLAIMED IS:

1. A system for producing a cladding on a substrate, comprising:

a) a laser for processing materials and focusing means for directing and focusing a laser light beam from said laser onto a substrate surface, a substrate holder and positioning means for adjusting the position of the laser light beam and the substrate with respect to each other, and powder injection means for injecting powder onto said substrate;

b) image detection means for capturing images of an interaction region between said laser light beam and powder injected onto said substrate surface; and

c) a computer control means connected to said laser, said positioning means and said powder injection means, and said computer control means including image processing means for the processing images of the interaction region between said laser light beam and powder injected onto said substrate surface and extracting from said images pre-selected properties of the growing clad in real-time, said computer control means including processing means to compare said pre-selected properties of the growing clad in real-time to desired values of said pre-selected properties of the growing clad produced by an effective model of cladding growth by laser processing of powder, said computer control means responsively adjusting parameters of the laser light beam, powder feedrate and positioning means based on differences between the extracted

values of the pre-selected properties of the growing clad in real-time and the desired values of the pre-selected properties of the growing clad.

2. The system according to claim 1 wherein said computer control means includes modeling means to model an object, and extract from said model the desired values for the pre-selected properties of the growing clad in real-time, and wherein said image processing means includes pattern recognition processing means to extract the pre-selected properties of the growing clad in real-time from images captured by the image detection means, said computer control means including intelligent process controller means interfaced to said laser, said substrate positioning means and said powder injection means for adjusting the laser parameters, substrate holder velocity, powder feedrate and orientation of powder stream directed onto the surface of the substrate, and wherein said modeling means and said image processing means are each connected to said intelligent process controller means which adjusts the parameters of the laser light beam, substrate holder velocity, powder feedrate and orientation of powder stream directed onto the surface of the substrate based on the differences between the extracted values of the pre-selected properties of the growing clad in real-time and the desired values of the pre-selected properties of the growing clad.

3. The system according to claim 2 wherein said intelligent process controller

means is a fuzzy logic controller comprising fuzzy logic membership functions, an interference engine and a defuzzification module, wherein said fuzzy logic membership functions are utilized to fuzzify the difference between the first input signals which are the pre-selected properties of the growing clad in real-time extracted by said pattern recognition processing means and second input signals which are the desired values of the pre-selected properties of the growing clad, and wherein the interference engine combines the fuzzified difference between first and second input signals using the said rules, and wherein the defuzzification module defuzzifies the outputs of the interference engine to convert them back into quantitative values, said quantitative values being output from the intelligent controller and sent to the laser, positioning device and powder feeder for adjusting the laser parameters, substrate position and powder feed parameters.

4. The system according to claim 3 wherein said pre-selected properties of the growing clad in real-time include dimensions of the clad, roughness of the clad and rate of solidification of the clad.

5. The system according to claim 1 wherein said laser parameters include beam size of the laser light beam focused onto the substrate surface and energy of the laser light beam.

6. The system according to claim 5 wherein said laser is a pulsed laser and wherein said laser parameters include pulse rate of the laser and pulse duration of each laser light pulse produced by the laser.

7. The system according to claim 2 wherein said pattern recognition processing means extracts a border of a bright area between molten and non-molten regions on the surface in the images detected by the detection means, and from the border calculating dimensions and angle (α) of a melt pool at the solid/liquid interface between the melted surface and powder and solid surface, and from the angle α determining the rate of solidification.

8. The system according to claim 7 wherein said dimensions of the clad calculated by the pattern recognition software includes height of the clad, and wherein said intelligent process controller means adjusts the parameters of the laser light beam, substrate holder velocity, powder feedrate and orientation of powder stream directed onto the surface of the substrate in order to maintain a selected height of the melt pool, a selected angle α and substantially suppress fluctuations in said height.

9. The system according to claim 2 wherein said positioning means is connected to said substrate holder for moving said substrate holder with respect to said laser beam.

10. The system according to claim 9 wherein said positioning means includes speed adjustment means for adjusting a speed of the substrate holder with respect to the laser light beam.

11. The system according to claim 9 wherein said focusing means for directing and focusing a laser light beam includes adjustable focusing optics for adjusting a beam size of the laser light beam on the surface of the substrate.

12. The system according to claim 1 wherein said laser is a continuous wave (CW) or pulsed laser beam.

13. The system according to claim 1 wherein said image detection means is at least two charge coupled device (CCD) cameras positioned in a pre-selected orientation with respect to each other and the substrate surface.

14. The system according to claim 1 wherein said image detection means is a plurality of charge coupled device (CCD) cameras disposed about said substrate for capturing a plurality of images.

15. A method for producing a cladding on a substrate, comprising:

a) injecting powder onto a surface of a substrate and directing and focusing a laser light beam having effective laser light beam parameters onto the substrate surface;

b) capturing images of an interaction region between the laser light beam and the powder injected onto the substrate surface; and

c) processing the captured images of the interaction region between the laser light beam and powder injected onto the substrate surface and extracting from the images pre-selected properties of the clad in real-time, and calculating a difference between the extracted pre-selected properties to desired values of the selected properties produced by an effective model of cladding growth by laser processing of powder, and using the difference to adjust processing parameters to substantially give the desired real time values of the selected properties of the clad.

16. The method according to claim 15 wherein the step of capturing images of an interaction region between the laser light beam and the powder injected onto the substrate surface includes capturing the images with at least two image detectors, and wherein the step of processing the captured images includes producing a binary black and white image in which black indicates one of the melting and solid areas of the clad and substrate respectively and the white areas indicates the other.

17. The method according to claim 16 wherein the step of processing the captured images includes projection of the images received from the at least two image detectors onto a reference plane using a transformation matrix that is

obtained based on orientations of the at least two image detectors with respect to the reference plane.

18. The method according to claim 19 wherein the reference plane is the substrate plane.

19. The method according to claim 19 wherein the step of processing the captured images includes merging of images received from the at least two image detectors using an effective morphological structuring element neighborhood method, and to obtain therefrom two matrices, one of the matrices being a boundary matrix representing the clad's boundaries on the substrate and another matrix being an overlap matrix representing the overlap between the two images captured by the at least two image detectors.

20. The method according to claim 19 wherein the step of extracting selected properties of the clad in real time includes determination of the clad's dimensions using the boundary and overlap matrices, wherein a width of the clad is determined using the boundary matrix and the combination of the boundary and overlap matrices and the binary images are used to extract the height and angle (α) of a melt pool at the solid/liquid interface between the melted surface and powder and solid surface.

21. The method according to claim 20 wherein the width of the clad is calculated based on the number of bright pixels in a pre-selected column of the boundary matrix.

22. The method according to claim 20 wherein an uncalibrated height of the clad for any corresponding column in the boundary and overlap matrices is extracted by counting a number of pixels between the clad's boundary and the overlap boundary matrices.

23. The method according to claim 22 wherein an actual height of the clad is obtained using a scaling factor of the images and angles of the image detectors with respect to the substrate to scale the uncalibrated height of the clad.

24. The method according to claim 20 wherein angle (α) of a melt pool at the solid/liquid interface is obtained directly from the binary images captured by the at least two image detectors, and wherein the angle between the border of a bright area in a tail of the melting pool seen by each image detector and a reference horizontal line along with a relative orientation of the image detectors and a clad trajectory is used to extract the solid/liquid interface angle α.

25. The method according to claim 20 including calibrating the at least two image detectors using an image of a standard with known dimensions, wherein

after calibrating the at least two image detectors calculating a corresponding location of any pixel in the matrices.

26. The method according to claim 20 wherein the step of calculating a difference between the extracted pre-selected properties to preferred values of the selected properties produced by an effective model of cladding growth by laser processing of powder includes fuzzifying the difference between the extracted pre-selected properties of the growing clad in real-time and the desired values of the pre-selected properties of the growing clad, combining the fuzzified difference between the extracted pre-selected properties and the desired values of the pre-selected properties of the growing clad using the said interference engine and set rules producing fuzzified outputs, and defuzzifies the fuzzified outputs producing quantitative values, sending the quantitative values to the laser, positioning device and powder feeder for adjusting the laser parameters, substrate position and powder feed parameters.

27. The method according to claim 26 wherein the processing parameters include parameters of the laser light beam, substrate holder velocity, powder feedrate and orientation of powder stream directed onto the surface of the substrate.

28. The method according to claim 27 wherein the parameters of the laser light beam include beam size of the laser light beam focused onto the substrate surface and energy of the laser light beam.

29. The method according to claim 29 wherein the laser light beam is a pulsed laser light beam and wherein the laser parameters include pulse rate of the laser and pulse duration of each laser light pulse.

30. The method according to claim 15 wherein the pre-selected properties of the clad include height, width, rate of solidification and clad roughness.

31. The method according to claim 27 wherein the step of adjusting the processing parameters to give desired real time clad properties includes adjusting parameters of the laser light beam, substrate holder velocity, powder feedrate and orientation of powder stream directed onto the surface of the substrate in order to maintain a selected height of the melt pool and substantially suppress fluctuations in said height.

32. A method of producing an iron-aluminum clad on a surface of a substrate by laser processing, comprising the steps of:

directing a stream of pre-mixed Fe and Al powders onto a surface of a substrate, pre-mixed to a specified bulk composition, and directing a laser beam onto the surface of the substrate which is simultaneously melted by the laser

beam along with the powder such that melted powder mixes with the molten substrate surface; and

cooling the heated area of the substrate where upon cooling, the molten substrate surface and molten powder solidify and a fusion bond is formed between the clad material and substrate.

33. The method according to claim 32 including

capturing images of an interaction region between the laser light beam and the pre-mixed Fe and Al powders powder injected onto the substrate surface; and

processing the captured images of the interaction region between said laser light beam and pre-mixed Fe and Al powders powder injected onto the substrate surface and extracting from the images pre-selected properties of the Fe-Al clad in real-time, and calculating a difference between the extracted pre-selected properties to desired values of the selected properties produced by an effective model of Fe-Al cladding growth by laser processing of powder, and using the difference to adjust laser processing parameters to substantially give the preferred real time values of said selected properties of the Fe-Al clad.

34. The method according to claim 32 wherein the substrate is mild steel.

35. The method according to claim 32 wherein the specified bulk composition is about Fe:20 wt % Al.

36. The method according to claim 32 wherein the laser beam is a pulsed laser beam.